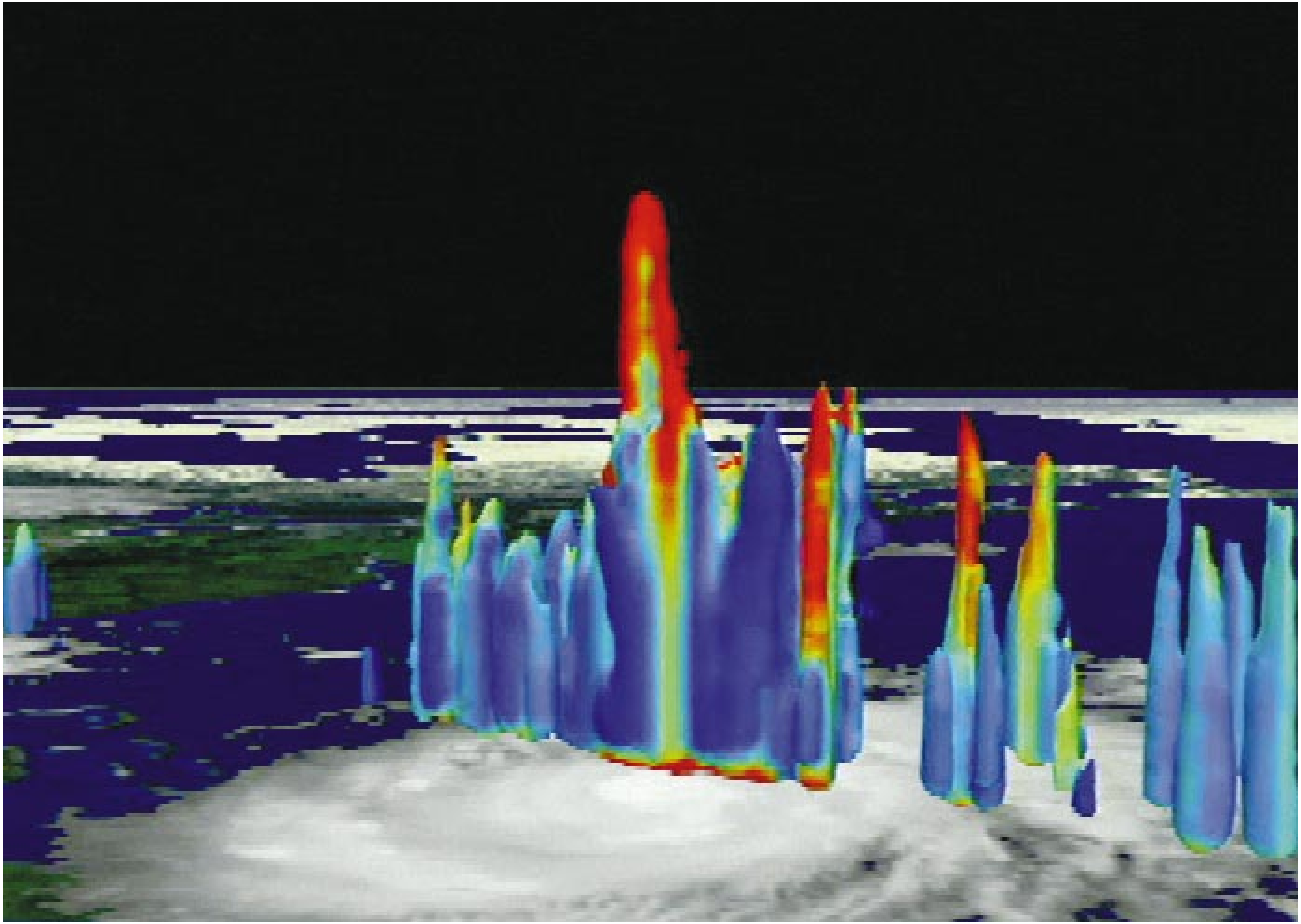
TRMM Hurricane Bonnie



TRMM Hurricane Bonnie

This compelling picture is a computer-enhanced image of Hurricane Bonnie showing a (cumulonimbus) storm cloud, towering like a sky scraper, 59,000 feet (18 kilometers) into the sky from the eyewall. These images were obtained on Saturday, Aug. 22, 1998, by the world's first spaceborne rain radar aboard the Tropical Rainfall Measuring Mission (TRMM) spacecraft, a joint U.S.-Japanese mission. Launched in the fall of 1997, the TRMM spacecraft continues to provide exciting new insight into cloud systems over tropical oceans.

By comparison, the highest mountain in the world, Mt. Everest, is 29,000 feet (9 kilometers) and the average commercial jet flies at barely one-half the height of the Bonnie's cloud tops.

Scientists believe that towering cloud structures like this are probably precursors to hurricane intensification. This was the situation with Bonnie whose central pressure dropped from 977 millibars to 957 millibars in the subsequent 24 hours.

TRMM is the first mission dedicated to measuring tropical and subtropical rainfall through microwave and visible infrared sensors, including the first spaceborne rain radar. The Precipitation Radar aboard TRMM is the first rain radar ever to be launched into space. It measures precipitation distributions over both land and sea areas. Scientists say that TRMM is exceeding expectations for accuracy and resolution, and the spacecraft is providing unprecedented insights into rainfall producing cloud systems over tropical land masses and oceans.

Tropical rainfall comprises more than two thirds of global rainfall. It is the primary distributor of heat through the circulation of the atmosphere. Understanding rainfall and its variability is crucial to understanding and predicting global climate change. Our current knowledge of rainfall knowledge is limited, especially over the oceans. By using a low-altitude orbit of 217 miles (350 kilometers), TRMM's complement of state-of-the-art instruments is providing more accurate measurements than ever before. These new instruments are increasing knowledge of how rainfall releases heat energy to drive the air circulation. Global rainfall is the primary distributor of heat through atmospheric circulation. The 1997-98 El Niño serves as a perfect example of the atmospheric circulation changes that can result from a displacement of the normal precipitation patterns in the central Pacific. More precise information about this rainfall and its variability is crucial to understanding and predicting global climate and climate change.

A tropical rain systems such as typhoons, hurricanes and monsoons produce floods worldwide. According to the National Weather Service's Tropical Prediction Center (a.k.a. National Hurricane Center), a tropical cyclone is the general term applying to a cyclonic circulation occurring over tropical oceans. A tropical cyclone is a giant wind machine or "heat engine" involving approximately one million cubic miles of atmosphere that converts the energy of the warm tropical ocean into one of the Earth's most intense storms, often generating wind speeds exceeding 155 mph. Composed of bands of thunderstorms, spiraling-in toward the center, it often produces torrential rains.

Hurricanes are products of the tropical ocean and atmosphere. Powered by heat from the sea, hurricanes are steered by the easterly trade winds and the temperate westerlies as well as by their own ferocious energy. Around their core, winds grow with great velocity, generating violent seas. Moving ashore, they can produce a tremendous storm surge while spawning tornadoes and producing torrential rains and floods. According to the National Hurricane Center, on average, 10 tropical storms (six of which become hurricanes) develop over the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico each year.

Tropical rainfall affects the lives and economics of half the Earth's population—residents of developing countries in or near the Earth's tropics. Rainfall variation in the tropics also can affect the weather in locations thousands of miles away, influencing the lives and livelihoods of populations worldwide. TRMM is a joint project between the United States and Japan. The National Space Development Agency of Japan (NASDA) provided the Precipitation Radar (PR) and an H-II rocket to launch the TRMM observatory in November 1997. NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Md., fabricated the observatory's structure and support systems, integrated and tested the spacecraft, provided two science instruments and operates the TRMM satellite via NASA's Tracking and Data Relay Satellite System (TDRSS). Two other instruments were provided by NASA's Langley Research Center, Hampton, VA, and NASA's Marshall Space Flight Center, Huntsville, AL.

TRMM is part of NASA's Earth Science Strategic Enterprise, a long-term research program designed to study the Earth's land, oceans, air, ice and life as a total system.

TEACHER ACTIVITY

The Tropical Rainfall Measuring Mission (TRMM) Satellite has a collection of instruments designed to remotely-sense rainfall in tropical regions of the globe. One unique aspect of TRMM is that it carries the first spaceborne weather radar. Weather radar transmits microwaves and then measures the waves reflected back to it. This is called backscatter. It is the backscatter energy that is converted into radar reflectivity values and rainfall rates useful to scientists and the public.

Raindrops, ice particles (snow, hail) and cloud droplets are examples of moisture found in clouds. Meteorologists call these hydrometeors. Hydrometeors vary in size and shape due to the conditions within the clouds such as temperature and convective motions. By analyzing the size of hydrometeors such as raindrops and the number of particles (or drops) within a cloud, the amount of rainfall can be determined.

Using this simple version of a much more complex weather equation,

Z = D6 where Z = Radar Reflectivity and D = drop diameter, students can simulate the method of raindrop analysis used by meteorologists.

Materials:
Powdered sugar or cornstarch, sifter, drop production device (plant mister, spray bottle, or sprinkler bottle) with water, waxed paper, metric ruler, calculator.

Procedure:
Lay out a piece of waxed paper the length of a table or desk. Sift a smooth, even layer of powdered sugar or cornstarch over the waxed paper. Create a sample of raindrops that may be found in a cloud by releasing drops of water above the powdered surface with your drop production device. (Note: height and intensity of drop release will affect formation of droplets on the sugar surface. For best results, do not spray water directly on the sugar surface.)

Section off an area of raindrops 10cm. X 10cm. Count the number of drops produced in the unit area and classify them into drop-size categories based on their diameter, measured with a metric ruler. (Example: you may have 5 drops at 2mm., 3 drops at 1 mm., and 10 drops at 0.5 mm.)

What size were most of the raindrops?

Were all the raindrops the same size? In reality, are all the raindrops that fall from clouds the same size?

For each size drop you tallied, multiply the size to the 6th power and then multiply by the number of drops that were that size. Example: 5 x 2 mm6 = 320 mm6

Now, add all the products together. This sum is the radar reflectivity.

Example: Z = (5 x 2 mm6) + (3 x 1 mm6) + (10 x 0.5 mm6)

What has a larger affect on determining reflectivity, a large number of small drops or a small number of large drops?

Using a relationship such as: Z=200R1.6 rainrate can be calculated by solving for R which will be in mm/hr.

What are some reasons that radar is useful for measuring rainfall as opposed to a rain gauge? What are some advantages of measuring rainfall from space around the tropical regions of the Earth?

More information on TRMM is available via the Internet at http://trmm.gsfc.nasa.gov

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